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EFFICIENCY AND PERFORMANCE OF THE INTERPORTS IN ITALY AND LINKAGES WITH THE ITALIAN PORTS

The Italian interport model

The Italian intermodal road-rail transport planning policy has been based on a unique national “interport model” promoted through the legislation for implementing interports that are beneficiaries of public contributions (Law 240/90).

The paper presents an analysis of the technical efficiency of Italian interports which have received public contributions in accordance with Law 240/90 and subsequent modifications, for the years 2006 and 2010. The estimates for technical efficiency obtained by the stochastic frontier production function have been used for creating a performance indicator to investigate the performance determinants of interports mainly with respect to linkages with sea ports.

The transport terminal efficiency

Port performances are generally evaluated by measuring single factors of production, or by comparing actual productivity with an optimal productivity over a specific period (Cullinane, Song, Wang, 2005, Tongzon, Heng, 2005).

In the last few years the policies more frequently pursued for the purposes of measuring efficiency and the productivity of the port terminals have been the Data Envelopment Analysis (DEA) and the Stochastic Frontier Analysis (SFA) which in certain cases have been applied by considering the connections with the terrestrial inland terminals among the variables for evaluating technical efficiency (Tongzon, 2001).

The measurement of the efficiency

Frontier represents the ‘best possible practice’ in the industry or sample studied. Once the frontier is estimated, efficiency then can be evaluated against the frontier.

Efficiency comprises technical efficiency, scale efficiency and allocative efficiency.

‘Technical efficiency’ is defined as the relative production between the observed output and the best possible output.

‘Scale efficiency’ is defined as the relative scale between the observed firm size and the optimal firm size.

‘Allocative efficiency’ is a measure of the benefit or utility derived from a proposed or actual choice in the distribution or apportionment of resources (Wang, Cullinane and Song, 2005).

The two stage approach: SFA and Performance Composite Index

This study has adopted a statistical analysis model of cross-section data relatives to the years 2006 and 2010 of a group of Italian interports of the parametric (econometric) probabilistic frontier-type production function (SFA) by considering a *y* output obtained by combining a group of *x* inputs.

In the second stage the utilized method to construct an composite indicator of performance (IPI) based on the production stochastic frontier, allow to study probabilistic estimates about several causes of the total productivity and the relative inefficiency.

The causal linkages between the IPI and its determinants

Moreover a linear regression (OLS) is carried out by considering the rail traffic of the Italian interports as dependent variable and the determinants included in the performance index IPI as independent variables, in order to identify and estimate potential causal links between the latter and rail traffic.

In the literature this technique has been applied in the sector of the port infrastructures for the elaboration of similar performance indices (Gosh, De, 2000, Tongzon, Heng, 2005). Finally a time-interval comparison has been carried out between the indices of efficiency and of performance of the Italian interports obtained during the two periods considered.

The stochastic frontier model

A production function is defined as the schedule of the maximum amount of output that can be produced from a specified set of inputs, given the existing technology. The problem is to determine empirically the maximum potential of a production unit. This means estimating the production possibilities frontier. The ratio of the observed to the maximum potential output obtainable from a particular set of inputs is the technical efficiency (TE) of a production unit.

Considering a composed error model, independently proposed by Aigner, Lovell and Schmidt (1977), the Stochastic Frontier Analysis (SFA):

$$\ln Y_i = \beta_o + \sum_{k=1}^{K} \beta_{ki} \ln X_{ik} + V_i - U_i$$

were:

$V_i \approx iidN(0, \sigma_v^2)$

U_i is a non-negative variable accounting for **inefficiency**

V_i and U_i are distributed independently of each other and of the regressor

The technical efficiency TE

The technical efficiency, *TE* of the *ith* unit is determined by:

$$\ln TE_i = \ln Y_i - \ln Y_i^* = \ln\left(\frac{Y_i}{Y_i^*}\right) = -U_i$$

$$TE_i = \exp(-U_i)$$

The technical efficiency of a unit lies between zero and one and will be inversely related to the inefficiency effect. Usually is assumed to be distributed non-negative half normal or other distribution as exponential but another single-tailed distribution could be assumed (Greene, 2003).

The parameters of stochastic frontier function are estimated by the Maximum Likelihood method (ML). Prediction of individual technical efficiencies involves the unobservable technical inefficiency effects *Ui*. The best predictor for *Ui* is the conditional expectation of *Ui*, given the value of : $\varepsilon_i = V_i - U_i$

PCA for the determination the IPI Index

PCA permits reducing the number of variables describing the profile of the units and reproducing the characteristics of the latter through a restricted number of new variables (principal components).

The principle components, uncorrelated amongst themselves for their construction, are linear combinations of the original variables; PCA in fact is a linear-type method which reconstructs hyper planes as optimal subspaces. A linear combination, in that it results from a considered sum of the original variables, it proves to be a useful model for constructing composite indicators, capable of summarizing complex phenomena.

The IPI Index

$$IPI = \sum_{k=1}^{n} W_K X_{ik}$$

- *IPI* represents the index of interport performance;

-*Wk* the weight of the *k-th* indicator from the F1 of the PCA;

-*Xik* is the standardized value for taking into account the different units of measurements of the *k-th* indicator for the *i-th* port.

(Tongzon, Heng, 2005; Gosh, De, 2005).

Significance of the variables and differences over time

The verification of a relationship of linear dependence between the two variables Rail traffic and IPI allows us to consider the rail traffic as a valid proxy of port performance.

Therefore the assess the statistical significance of the variables selected for the composite indicator, a linear regression OLS has been carried out by considering the total rail traffic handled by the interports as independent variable.

The performance indices of the Italian interports relating to two years a comparison has been made between a comparison index between the performance of the interports ($IPI^{i}_{t,t+1}$) between period *t* and period *t+1*.

A Malmquist Productivity Index ($MPI^{i}_{t,t+1}$) has also been elaborated by considering the efficiency estimates between two periods *t* and *t+1* based on the frontiers at time *t* and at time *t+1* (benchmark technology years).

MLE Normal/Half-normal Estimations of the Production Function Rail Traffic Model

Dependent Variable: lnY_i (natural logarithm of the total rail traffic 2006)	Value	SD	z	Pr > | z |
Constant	0.954	2.822	0.34	0.735
ln RAILWAY TERMINAL	1.017	0.278	3.66	0.000
ln TOTAL LOGISTIC OPERATORS	0.483	0.158	3.04	0.002
Observations	15			
σ^2	1.615(*)	1.185		
$\lambda = \sigma_u / \sigma_v$	2.813(*)	1.007		
$\gamma = \sigma_u^2 / \sigma^2$ *with* $\sigma^2 = \sigma_u^2 + \sigma_v^2$	0.886			
Log likelihood	-18.1384(***)			
Dependent Variable: lnY_i (natural logarithm of the total rail traffic 2010)	Value	SD	z	Pr > | z |
Constant	4.4296	0.0001	32771.95	0.000
ln RAILWAY TERMINAL	0.7291	0.0000	65312.09	0.000
ln TOTAL LOGISTIC OPERATORS	0.4448	7.80e-06	57034.36	0.000
Observations	14			
σ^2	2.4198(***)	0.9146		
$\lambda = \sigma_u / \sigma_v$	4.38e+07(***)	0.2939		
$\gamma = \sigma_u^2 / \sigma^2$ *with* $\sigma^2 = \sigma_u^2 + \sigma_v^2$	1.0000			
Log likelihood	-16.34716(***)			

*** significance level at 1%; ** significance level at 5%; * significance level at 10%.

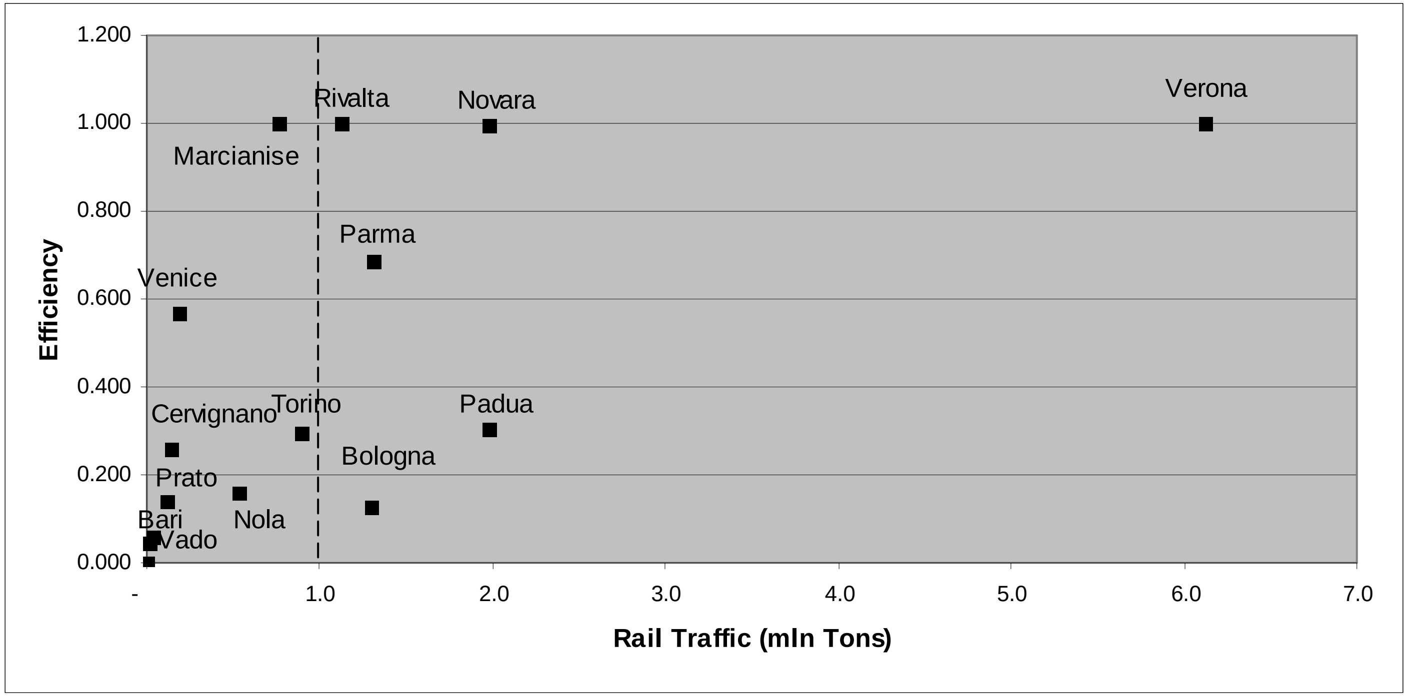
Technical Efficiency level Ranking 2006 and 2010

Interport	***TE***
NOVARA	0.8247
VENICE	0.7181
PARMA	0.7166
BARI	0.6612
VERONA	0.6552
MARCIANISE	0.6080
CERVIGNANO	0.5403
TURIN	0.5136
PADUA	0.3615
BOLOGNA	0.3604
PRATO	0.2756
RIVALTA SCRIVIA	0.2631
NOLA	0.2343
LEGHORN	0.1427
VADO LIGURE	0.1177
Mean Efficiency	*0.4662*

Interport	***TE***
VERONA	1.0000
RIVALTA SCRIVIA	1.0000
MARCIANISE	1.0000
NOVARA	0.9951
PARMA	0.6855
VENICE	0.5704
PADUA	0.3047
TURIN	0.2955
CERVIGNANO	0.2583
NOLA	0.1583
PRATO	0.1431
BOLOGNA	0.1294
BARI	0.0610
VADO LIGURE	0.0458
Mean Efficiency	*0.4748*

The Leghorn interport does not present rail traffic for 2010

Estimated Technical Efficiency and Rail Traffic – 2010

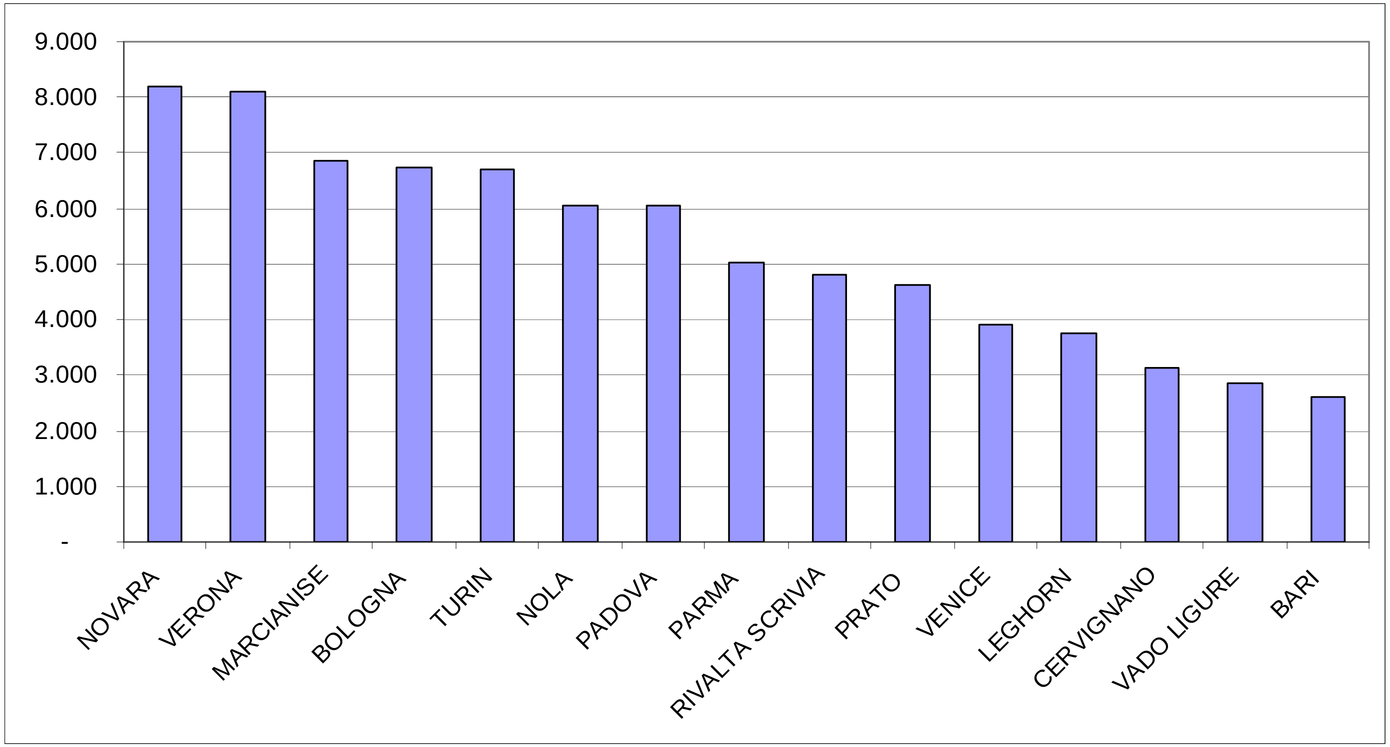


Interport Performance Index Ranking 2006 and 2010

	Interport		***IPI***
1	NOVARA		8.316
2	VERONA		8.094
3	BOLOGNA		7.150
4	TURIN		7.109
5	MARCIANISE		6.706
6	PADUA		6.331
7	NOLA		6.273
8	PARMA		5.261
9	PRATO		4.858
10	RIVALTA SCRIVIA		4.310
11	VENICE		4.165
12	LEGHORN		3.981
13	CERVIGNANO		3.463
14	BARI		3.183
15	VADO LIGURE		3.000
		Mean	5.480
		SD	1.782

	Interport		***IPI***
1	NOVARA		8.181
2	VERONA		8.105
3	MARCIANISE		6.845
4	BOLOGNA		6.726
5	TURIN		6.703
6	NOLA		6.062
7	PADUA		6.061
8	PARMA		5.037
9	RIVALTA SCRIVIA		4.795
10	PRATO		4.622
11	VENICE		3.911
12	LEGHORN		3.752
13	CERVIGNANO		3.121
14	VADO LIGURE		2.866
15	BARI		2.594
		Mean	5.292
		SD	1.829

Interport Performance Index - 2010



Determinants of Interport Performance OLS – 2006 and 2010

Variables	*Coefficients*	*SD*	*t*	*Pr > |t|*
Constant	9.636**	2.794	3.449	0.0107
Ln(VAR1)	1.002**	0.305	3.287	0.0134
Ln(VAR2)	0.301	0.629	0.479	0.6463
Ln(VAR3)	0.989***	0.278	3.552	0.0093
Ln(VAR4)	2.139***	0.554	3.865	0.0062
Ln(VAR5)	0.162	0.308	0.525	0.6158
Ln(VAR6)	-0.269	1.363	-0.197	0.8494
Ln(VAR7)	-0.160	1.394	-0.115	0.9116
R^2	0.946			
F-test	17.60***			0.0006
Durbin-Watson	2.0336			
White test				0.3782
Breusch-Pagan test				0.9723

Variables	*Coefficients*	*SD*	*t*	*Pr > |t|*
Constant	8.923**	2.788	3.201	0.019
Ln(VAR1)	0.817***	0.149	5.480	0.002
Ln(VAR2)	0.339	0.597	0.568	0.591
Ln(VAR3)	0.801**	0.240	3.330	0.016
Ln(VAR4)	1.714**	0.482	3.557	0.012
Ln(VAR5)	0.146	0.237	0.617	0.560
Ln(VAR6)	-0.184	1.526	0.120	0.908
Ln(VAR7)	0.079	1.599	0.050	0.962
R^2	0.966			
F-test	24.729***			0.0005
Durbin-Watson	1.3171			
White test				0.3738
Breusch-Pagan test				0.2816

Y = ln Rail Traffic.

*** significance level at 1%; ** significance level at 5%; * significance level at 10%.

Rankings of Interports by Indices 2006-2010

	Interport	$IPI^{i}_{t,t+1}$		*Interport*	$MPI^{i}_{t,t+1}$
1	RIVALTA SCRIVIA	1.113	1	RIVALTA SCRIVIA	4.070
2	MARCIANISE	1.021	2	MARCIANISE	2.125
3	VERONA	1.001	3	VERONA	1.020
4	NOVARA	0.984	4	VENICE	1.000
5	NOLA	0.966	5	VADO LIGURE	0.961
6	PARMA	0.957	6	PRATO	0.952
7	PADUA	0.957	7	PARMA	0.870
8	VADO LIGURE	0.955	8	PADUA	0.715
9	PRATO	0.951	9	NOLA	0.713
10	TURIN	0.943	10	TURIN	0.660
11	LEGHORN	0.943	11	NOVARA	0.536
12	BOLOGNA	0.941	12	CERVIGNANO	0.532
13	VENICE	0.939	13	BOLOGNA	0.461
14	CERVIGNANO	0.901	14	BARI	0.111
15	BARI	0.815	15	LEGHORN	0.000

Conclusions

The main results of this study shows a positive relationship between technical efficiency, intermodal traffic volume (more then 1 million tons), investment cost and the chosen performance index (IPI).

The variables related to the operational linkages with the Italian ports and the possibility of developing maritime traffic showed no particularly significance for the rail function and performance of the Italian interports.

Technical Efficiency has considerable relevance for the competitive performance over time.

The general Italian policy of intermodal road-rail transport planning, followed by a unique “national model” promoted with late-1980s legislation (Law 240/90), in few cases has given positive results and mainly in North Italy.